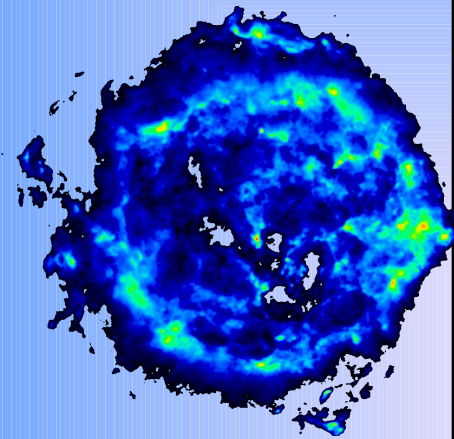


Constraints on Beaming in Gamma-Ray Bursts

C. Dermer (NRL), K. Mitman (IJHSST, NRL), J. Chiang (



GRB	Redshift	Peak Power (10^{52} ergs s $^{-1}$)	Energy (10^{52} ergs)
970228	~1.5-2.6	3-10	1.3
970508	0.835	0.13	0.6
971214	3.418	4	30
980329	~4	~10	~20
980425	0.0084	0.000011	0.00008
980703	0.966	0.13	11
990123	>1.6	4	>300!!

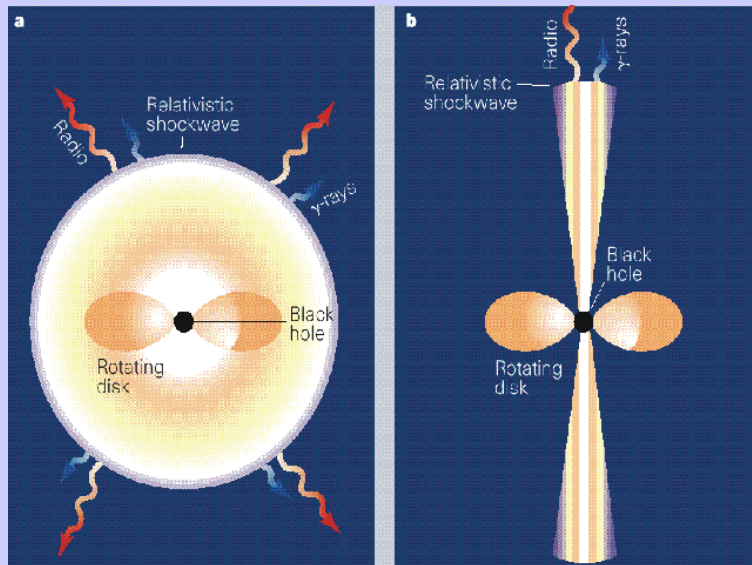
$$1 M_{\odot} c^2 = 2 \times 10^{54} \text{ ergs}$$

- **Degree of beaming determines**

- the total burst energy: $E \rightarrow E (\Delta\Omega/4\pi)$
- the number of GRB sources $N \rightarrow N/(\Delta\Omega/4\pi)$
- the nature of the sources which produce GRBs

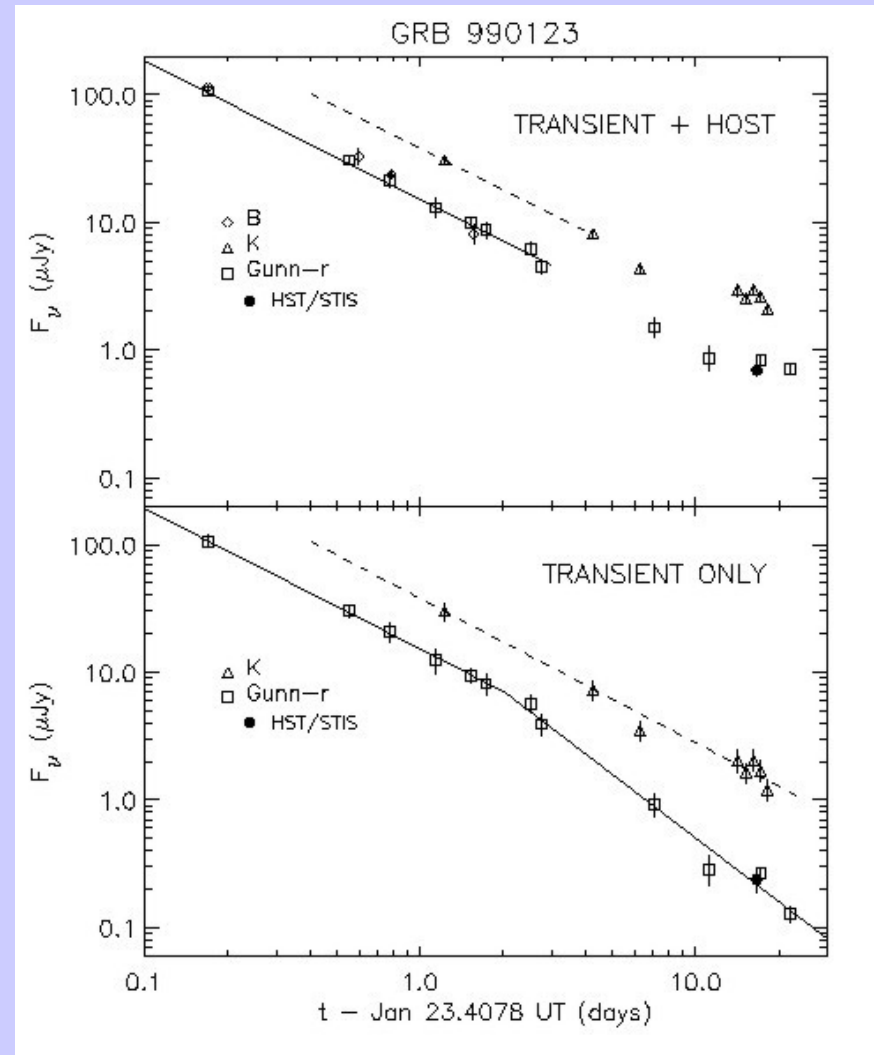
GRB 990123

- Break in temporal index evidence for beaming?



Baron, E. *Nature*, **395**,
635, 1998 (reproduced by
permission)

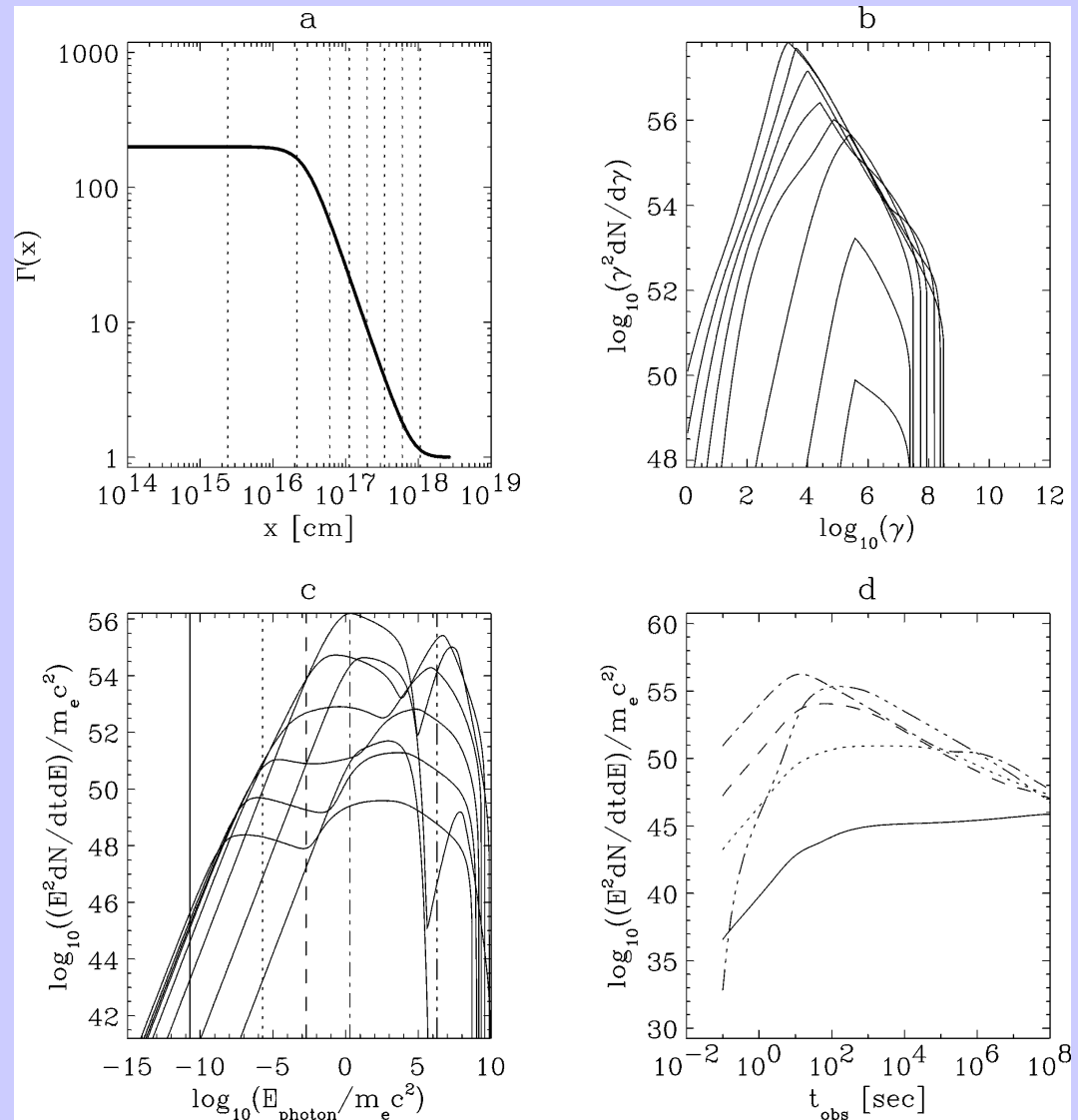
April 12,



Kulkarni, S. et al. *Nature*, submitted
(1999) ([astro-ph/9902272](https://arxiv.org/abs/astro-ph/9902272))

Blast Wave Model in the External Shock Paradigm

- Explain all GRB phenomenology with single impulsive event; variability due to inhomogeneities in surrounding medium
- Observer sees emission from Doppler cone for portions of blast wave directed within $1/\Gamma$ of line-of-sight to observer



$$E_{200} = 10^{54} \text{ ergs}; \Gamma = 200; n = 100 \text{ cm}^{-3}$$

C. Dermer & J. Chiang (1999) in *High Energy Processes from Accreting Black Holes*, ed. J. Poutanen and R. Svensson, in press ([astro-ph/9810222](https://arxiv.org/abs/astro-ph/9810222))

April 12,

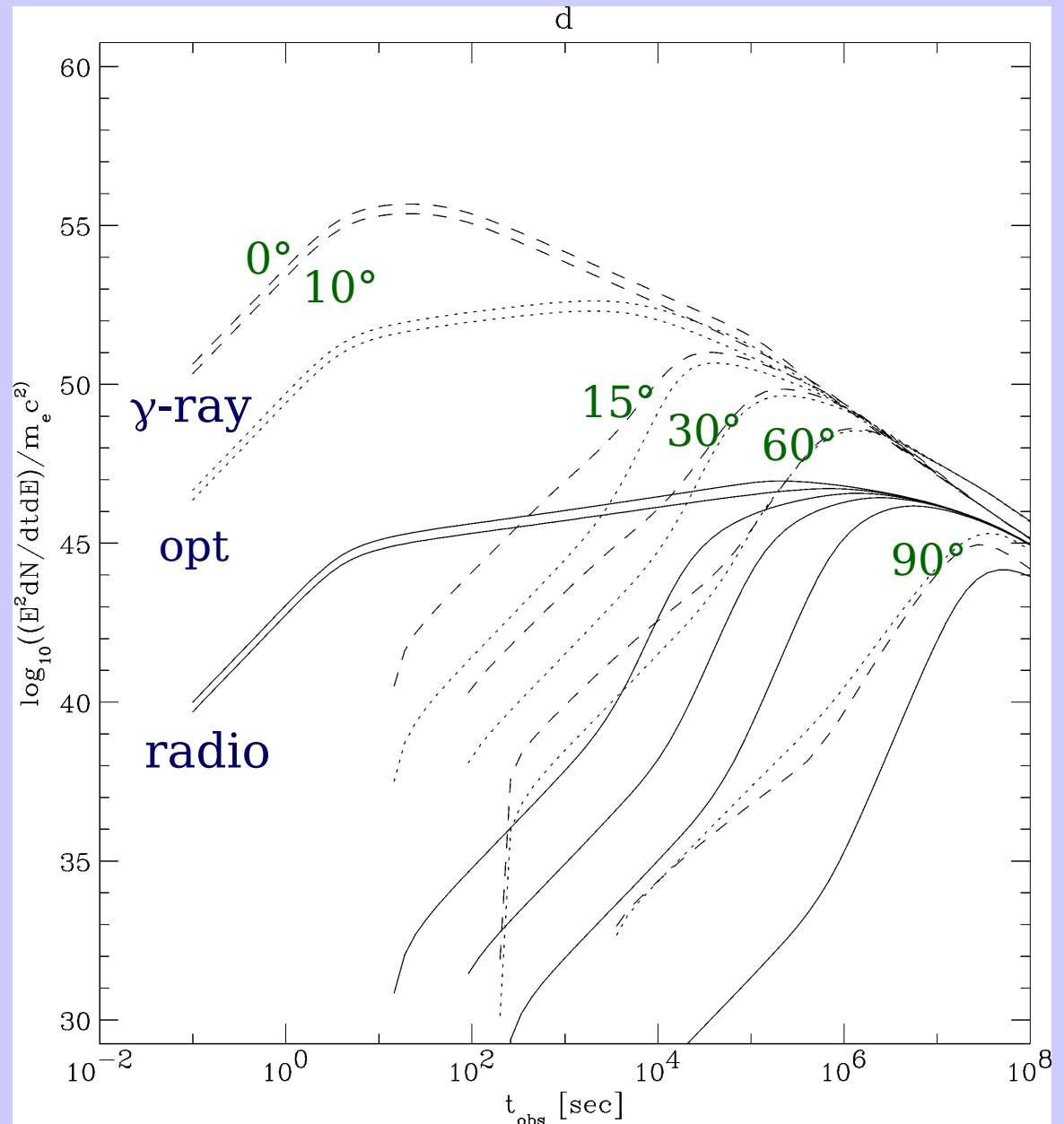
Beaming: Opening angle of jet ψ $= 10^\circ$

$$\partial E / \partial \Omega = 10^{54} \text{ ergs} / 4\pi$$

$$\Gamma = 300$$

$$n = 100 \text{ cm}^{-3}$$

- **Break in temporal indices**
- **Statistics of misaligned sources** (see Grindlay, *J. ApJ*, 510, 710, 1999)



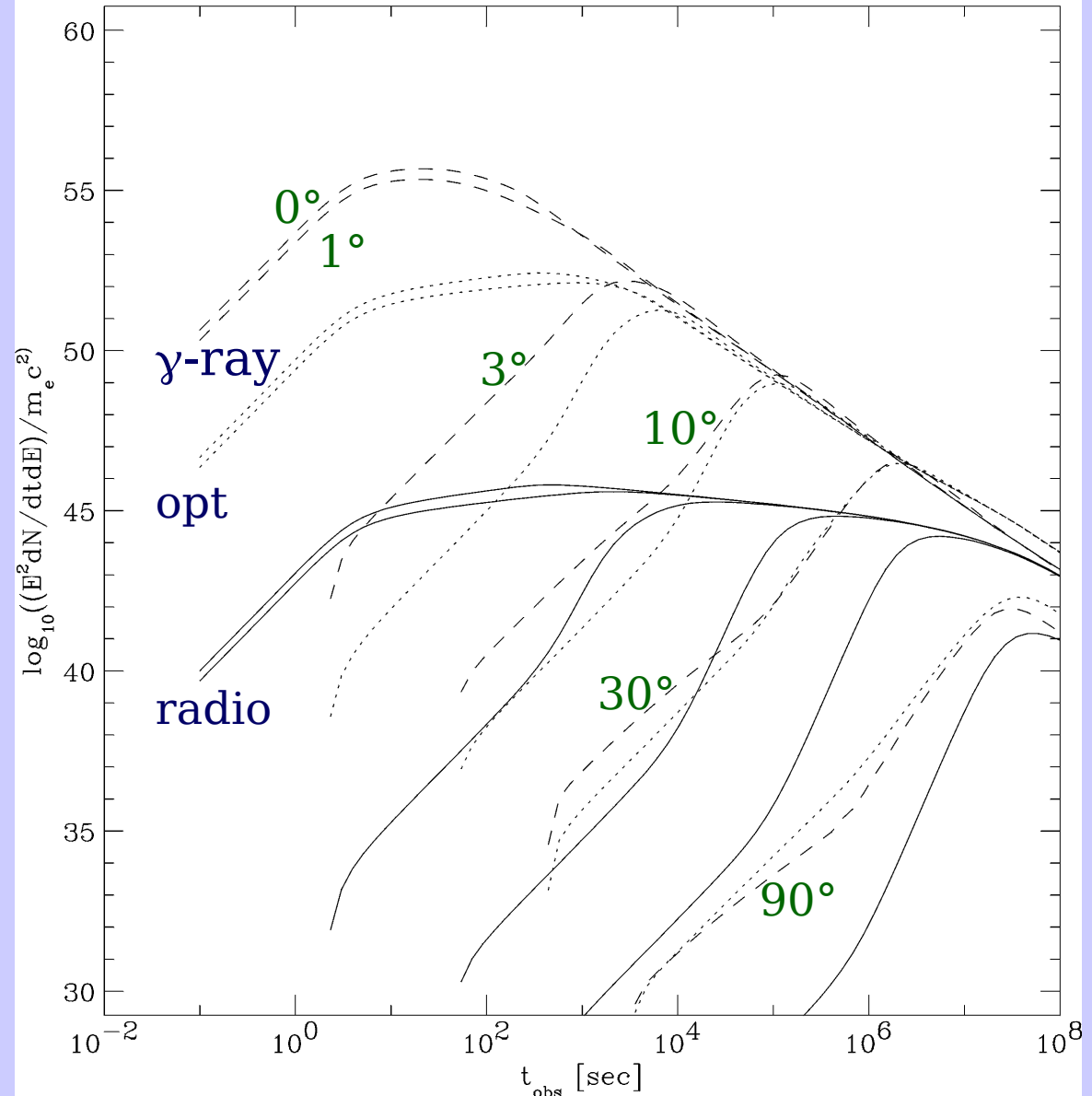
Beaming: Opening angle of jet ψ $= 1^\circ$

$$\partial E / \partial \Omega = 10^{54} \text{ ergs} / 4\pi$$

$$\Gamma = 300$$

$$n = 100 \text{ cm}^{-3}$$

- **No break in temporal indices**
- **Power law decay of temporal profile**

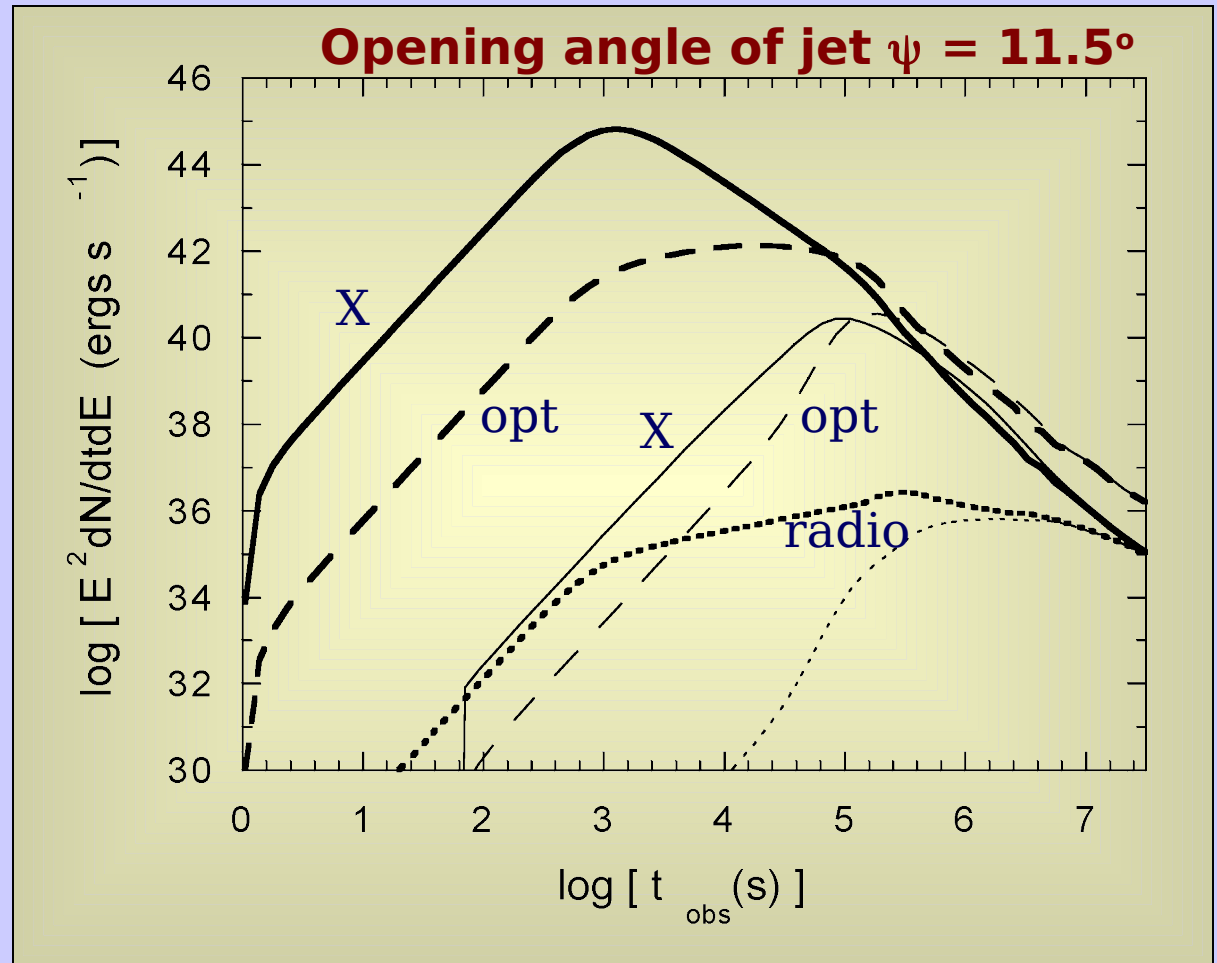


Beaming and Variability

Bold: along jet axis

Light: 20° off jet axis

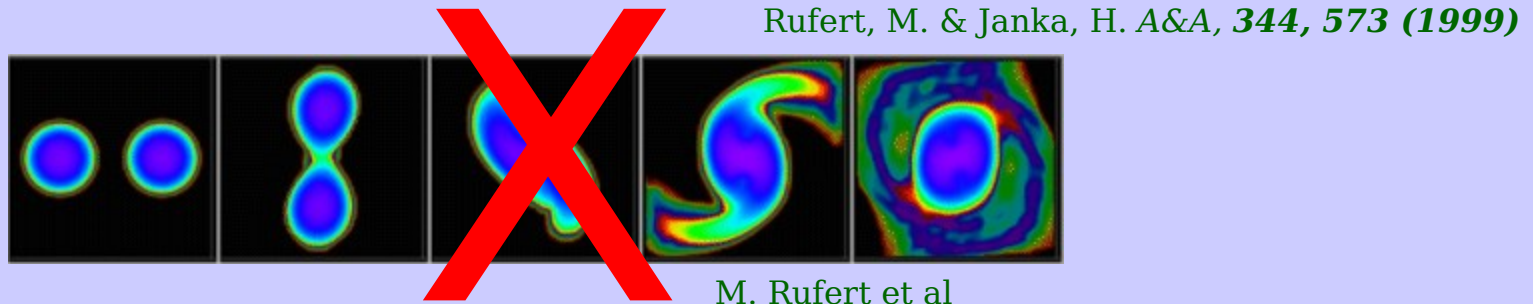
- **Preferentially detect flaring synchrotron sources at highest photon energies in flux limited surveys**



in *Veritas Workshop Proceedings*, ed. T. Weekes and M. Catanese, ***Astroparticle Physics***, in press ([astro-ph/9901324](#))

Are GRBs beamed?

- Break in temporal indices:
 - Beaming
 - Variation in density of circumburster medium
 - Cutoffs in electron distribution
- If beamed, minimum beaming angle > few degrees
 - → coalescing neutron star models ruled out (maximum radiative energy ~ 10^{49} - 10^{50} ergs)



This talk posted at <http://gamma.nrl.navy.mil/dap->